in astronomy or meteorology. Life and commerce and navigation would go on the same whether we believed that the earth went round the sun, or the sun round the earth. But in this matter of tempests and cyclones, trade and commerce can be very adversely affected if we teach an incorrect theory of their origin and motion. A captain can only hope to escape from the danger with which they threaten him by localizing, with some precision, the situation of the inner vortex. To do this he has but one guide, the direction of the wind. The use he makes of this guide in inferring the position of the ship with reference to that of the storm center will be materially affected by the views he holds concerning the motion of the wind in a cyclonic storm. A rule must be devised for his guidance without ambiguity, and one that can be followed without hesitation. Piddington and the older meteorologists held that the movement of the wind in a cyclone was circular. In this view they are followed by Mr. Faye. The result of this belief was the enunciation of the rule of eight points expressed something in this way: With the face turned to the wind extend the right arm. In the Northern Hemisphere you will point in the direction of the storm center. This rule can be supported only by ignoring a great mass of recent observations. The rule asserts that the wind blows at right angles to the radius, but it has been shown over and over again that in true cyclones the winds are strongly inclined inwards, not directly to the center, but approaching it by a spiral. A more accurate rule has been deduced and is supported by weighty authorities, but not by Mr. Faye. In the Northern Hemisphere, with face to the wind, the direction of the center is from ten to eleven points to the right-hand side. To go back to the old rule of Piddington is a retrograde step, but the mischief does not end there. The distrust likely to be awakened in the mind of the seaman by the spectacle of disaccord among the scientific authorities can have the most disastrous results. The ordinary seaman asks for a clear and precise rule on which he can act without argument or question, while his whole attention is directed to the preservation of his ship. M. Faye is great authority. His name is one to conjure with, and it is not unlikely that the rules which he quotes with approval will be copied into English books by those who compile manuals of brief and ready directions for navigation, and in this way perpetuate an evil against which a mass of scientific evidence, collected in less accessible quarters, is powerless.

THE OBSERVATION OF HALOS.

The communication on a preceding page from the Rev. K. Schipps illustrates the remarks made in a recent number of the MONTHLY WEATHER REVIEW to the effect that meteorology offers innumerable fields of interest to the special observers, and there doubtless are a few in this country who, as students of physical or optical meteorology, will be glad to take up the subject of halos with the enthusiasm of the Halo Committee, represented by our learned correspondent. Students of meteorology will profit by a study of the treatment of this subject in the first and third volumes of the Traité d'Optique (Paris, 1893), by Mascart, the Director of the Meteorological Central Bureau of France. The ordinary rainbow is a well-known illustration of a solar halo, whose angular distance from the sun is from 138° to 140°, that is to say, about 40° or 42° from the anti-solar point or from the direction of the shadow of the observer. The general theory of the rainbow and its supernumerary arcs, as deduced from the wave theory of light, is given by Mascart (Chapter V), but a most elaborate investigation of the subject, together with a series of exact observations of rainbows, has just been published by Prof. J. Pernter, the newly-appointed successor to Prof. Dr. Hann as Director of the Central Institute for Meteorology and Terrestrial Magnetism at Vienna.

With regard to the names of the halo phenomena referred to by Dr. Schipps as proper to be used in the observers' condensed descriptions, the following list, compiled from Mascart's Treatise, will be helpful:

Corona, or glory. A circle of light or color surrounding the sun or moon or any other luminary, either celestial or terrestrial; the angular radius of such circles very rarely exceeds 5°; the largest that has yet been observed is the so-called Bishop's circle of about 15° radius, first described by Sereno Bishop of Honolulu, in connection with the haze due to the eruption of Krakatoa, August 27, 1883.

Anti-solar coronas or anti-lunar coronas. Similar small circles of light or bands of color surrounding the anti-solar point, and seen with especial beauty when, from a mountain top or a balloon, the observer's shadow is cast upon the clouds, and sometimes when it is simply cast upon a meadow covered with dewdrops.

Shadow beams, or perspective beams, or solar beams, or beams of light and shade. These beams, due to the shadows of clouds in the sky, or of mountains and terrestrial objects when the sun is below the horizon, appear to converge toward the solar and the anti-solar points, and are widest apart in the region perpendicular to the line joining the sun with the observer. They are, in fact, parallel with each other, and the convergence is only an illusion of perspective.

Primary rainbow. A halo of 40° or 42° radius from the anti-solar point, a brilliant circle of spectrum colors.

Secondary bow, or secondary rainbow. A halo of feebler light than the primary rainbow, and having a larger radius, viz, from 50° to 54° from the anti-solar point. The secondary rainbow is sometimes called the reflected bow as though it were the reflection of the primary, but this is not proper.

Tertiary rainbow. A halo having a radius of 41° from the sun; quarternary rainbow, a halo of 44° from the sun; quinary rainbow, a halo of 54° from the anti-solar point. The 3d, 4th, and 5th orders of rainbow are too feeble to be ordinarily observed.

Supernumerary arcs. The colored fringes that border almost every system of rainbow colors, and especially on the inside of the secondary rainbow.

Reflected halos or reflected bows. These are sometimes seen by reflection, properly so called, from the smooth surface of rivers or lakes.

The white rainbow. A halo of between 33° and 42° radius from the anti-sun, described first by Mariott, but more frequently known as Ulloa's circle.

The peculiarities of all halos depend upon the size of the particles or drops of water, the uniformity in size and shape, the number of reflections within the drops, and the mutual distance of the drops or particles from each other. Ulloa's white rainbow appears to be formed, according to Mascart, by the overlapping of bows formed by a mixture of drops of all sizes.

The second set of optical phenomena are due to the presence of crystals of ice, hexagonal prisms, flat plates, and hexagonal pyramids, either alone or in combination with drops of water. The optical phenomena due to these may be designated by the following among other names:

Anti-sun or anthelion. The bright spot or point directly opposite the sun, or directly in the line of the shadow of the observer's head.

Halo of 22° radius from the sun.

Halo of 46° radius from the sun.

The tail of the halo; a projection attached to the halo of 22°, and also to the halo of 46°.

Parhelic circle. A horizontal white band passing through the sun and sometimes entirely around the heavens parallel to the horizon.

Parhelion of 22°. A bright spot on the parhelic circle 22° to the right and left of the sun.

Tail of the parhelion. A short extension of the bright light from the parhelion, or mock, or false sun, extending vertically or horizontally.

Parhelion of 46°. The bright spot 46° from the sun at the intersection of the halo of 46° with the parhelic circle. This parhelion also has a tail streaming along both its intersecting circles, especially the halo circle.

Paranthelia. The mock suns that appear when the true sun is very near the horizon and which can appear in the parhelic circle on either side of the anthelion and at about

46° and 82° distant from it. There is a third paranthelion at 38° and a fourth one at 60°, the latter being white.

Tangent arcs. These may be tangent at the top and bottom of the halo circle of 22°. When perfect they have two branches, one pair running off indefinitely and the other circumscribing the halo of 22°.

Circumzenithal parhelic circle. A horizontal circle tangent or quasi-tangent to the halo of 46°.

Lateral tangential arcs. These are arcs tangent to the lower part of the halo of 46° at points considerably to the right or left of the vertical circle from the zenith through the sun. Corresponding supra-lateral tangent arcs may also occur tangent to the same circle on the right and left hand sides of its summit; in fact, in one position only, the upper and lower lateral arcs may become continuous and inclose the halo of 46°.

Lateral arcs tangent to the halo of 22°. They are known as the arcs of Lowitz; they are of short extent and only clearly disengaged from the halo when the sun is quite high above the horizon.

Columns of light. Bright white columns passing vertically through the sun.

Solar cross. The intersection of a bright vertical column and a bright horizontal bar with the sun or the anti-sun at the center.

Oblique parhelic circle. This is analogous to the horizontal parhelic circle, except for its inclination.

Oblique arcs through the anthelion or through the sun. These are usually inclined about 30° to the vertical, or 60° to each other.

St. Andrew's cross. Two oblique arcs passing through the sun incline to each other at 60°.

As all these phenomena are due to the reflection and refraction of sunlight by crystals of ice floating in the air, the frequency of the phenomena will depend, other things being equal, upon the relative frequency with which crystals of the proper form and position occur in the sky. European observations gave Bravais the following results. (See Mascart, Optique, Vol. III, p. 518.) Let all the halo phenomena be divided into four classes, as follows:

I.—When the axes and facets of the ice crystals are distributed by chance, which is the great majority of cases, we perceive then only the two principal halos of 22° and 46°, and sometimes the halos due to prisms whose angles differ from the 60° or 90° that occur in the normal prisms of ice.

II.—When the prisms have a vertical axis they produce the parhelia of 22°, the quasi-tangential arcs to the halo of 46°, the parhelic circle, the para-anthelia of 60°, and the vertical columns or bright bands of light passing through the sun.

III.—When the plates of the ice crystals are vertical they produce the halos of 22° (the upper and lower parts of which are by far the brightest portions), the upper and lower arcs tangential to this halo, the lateral arcs tangential to the halo of 46°, and the parhelic circle.

IV.—When the lamellar crystals are unsymmetrically developed, so as to cause one of their diagonals to be vertical as they slowly fall through the air, they produce the extraordinary arcs tangential to the halo of 22°, the parhelia of 46°, the anthelia, the oblique arcs passing through the anthelia, and the similar arcs passing through the sun itself.

The relative frequency of these groups of phenomena, as indicated by the number of cases observed by Bravais, is:

I.—The great majority of cases.
II.—Two or three hundred times, or very frequent.
III.—Eighteen times.
IV.—Eight times.
II and III simultaneously.—Forty-five times.
II and IV simultaneously.—Three times.
III and IV simultaneously.—Once.
II, III, and IV simultaneously.—Six times.

THERMOMETER EXPOSURE.

It is frequently complained of the Weather Bureau temperatures that they relate to points in the atmosphere too high above the ground, and some remarks on this subject from our esteemed voluntary observer, Dr. A. C. Simonton, of San Jose, Cal., suggests the question, "What part of the atmosphere is of interest to man so far as temperature is concerned?" He answers this from the physician's point of view and says, "Evidently that part in which he lives." But to this we must add that man is also interested in a much wider range of temperature than this. We might even ask, "*Where* does man live? Does he wish the temperature at 5 or 6 feet above ground or at the surface itself? Does he wish it in the house or in the street; in the plowed field or in the forest; in the lowlands and ravines or on the highlands and plateaus; in the cool ocean breeze on the seashore or in the stifling hot air half a mile inland?" Evidently, there can be no restriction. The temperature of any special locality is of interest, but only when we are studying the phenomena of that locality. Even the reflected heat from a sandbank in the sunshine becomes of importance when we are studying the human life and the plant life that are subjected to it.

It was never supposed that the so-called regulation or standard instrument shelter would give us the temperature of the air at any of these special localities; thermometers placed therein give us very little idea of the nocturnal minimum temperature of the surface of leaves of grass and low tender garden vegetables, nor yet of the midday maximum temperatures of the surface of the soil. Special thermometers must be placed in special localities if we wish to know accurately these local temperatures. Thermometers whose bulbs are free to give and take radiant heat give us very little idea of the temperature of the air in contact with them because radiant heat passes through the air without affecting it very much, but it does affect the temperature of the bulb of a thermometer by nearly its full amount. It is, therefore, very nearly correct to say that a thermometer in the air indicates the average temperature due to the radiation between it and its material inclosure. If it is entirely surrounded by a shelter it gives the average temperature of the inside surface of that shelter. If its inclosure consists of grass or soil below it, trees and houses around it, clouds and blue sky above it, then the radiation between it and each of these affects it in proportion to their temperatures and the solid angles they subtend at its center. It would require a very strong wind or a violent whirling of the thermometer to produce enough convection of heat between it and the air to enable it to indicate a temperature that is even approximately close to that of the air. The so-called *ventilation of the thermometer* is the *first essential* in getting the temperature of the air and the *cutting off of all noxious radiation is the next essential.* As was explained in the Editor's "Treatise on Meteorological Apparatus and Methods," page 80, "The thermometer should neither give heat to nor receive heat from any object that has a temperature differing from that of the external air. When the thermometer is surrounded by a screen and fresh air is drawn into the screen, or blown in by the wind, it should show no change in temperature. When a thermometer is whirled rapidly in the free air, near the shelter, and at the same time protected from noxious radiations, it should give the same temperature as the thermometer within the screen." There are but two practicable ways of getting the temperature of the air at any given spot, viz, (1) let the thermometer be screened from radiation by placing it within one or two thin metallic tubes, and then whirling the whole combination rapidly, or (2) let the thermometer and screens be stationary and the air drawn rapidly over its surface and through the screens.

The temperature of the air is a very different matter from the temperature of a surface, whether it be a surface of soil,